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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

VON

THIS ISSUE

Ice Refrigeration

Compressor Lubrication

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THE TEXAS COMPANY

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LUBRICATION

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Ice Refrigeration Compressor Lubrication

EVAPORATION as an essential to refrigeration dates back to antiquity. Cooling by the evaporation of water was practiced by the ancient Greeks and Egyptians. Later it is to be presumed that they discovered the cooling effects of ice. The actual use of ice or snow for refrigeration purposes, however, can be credited to the Caesars, notably Nero, who employed an army of slaves for transportation of snow and ice from the Appennine Mountains. This was stored in insulated trenches in Rome and used for cooling wines and preserving the rare foods, fish and game which graced his banquet tables.

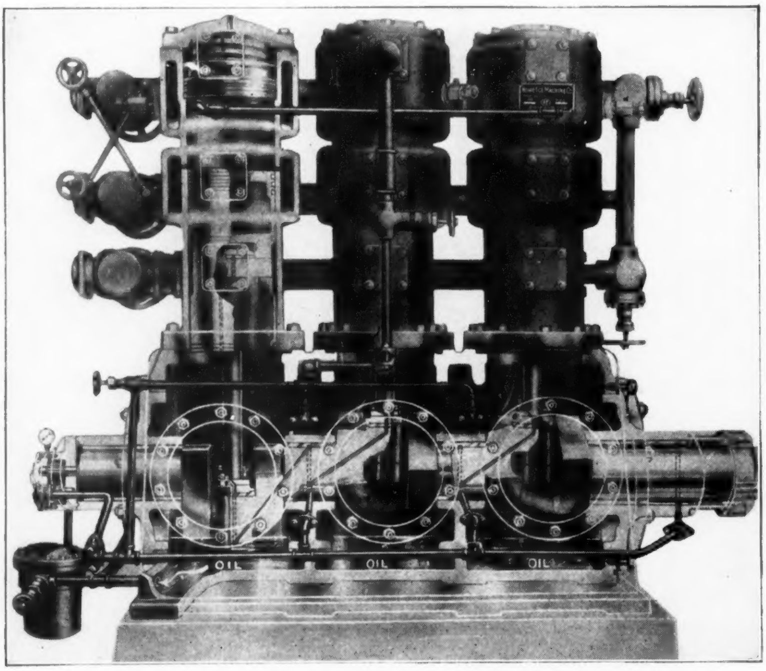
Later, the handling of ice was more scientifically approached, especially as civilization improved; slavery was discarded and the insulating properties of sawdust, hay, straw and cork were discovered. Then ice was cut in winter from frozen ponds or lakes and stored in suitably insulated buildings against the time when warm weather demanded its cooling properties. This procedure sufficed for many years, even approaching the latter part of the 19th century, when engineering talent was able to apply the technique of compression, and chemistry had isolated certain chemicals as suited to refrigeration by their expansion after they had been properly compressed. Ammonia was the first of these to be widely used, followed by carbon dioxide, and later by the variety of other chemicals so common to electric refrigeration and air conditioning today.

Ammonia, however, was the adjunct to ice refrigeration on a commercial scale. It was in 1873 that Linde and others developed the practicability of the ammonia compression machine. To these scientists must we therefore credit the marvelous development of the ice industry, the world-wide extension of mechanical refrigeration, and the fact that ice making and the direct or indirect cooling of air for cold storage compartments by means of certain chemicals having refrigerating properties has become one of the essential industries of modern civilization. In the preservation of foodstuffs refrigeration is in reality so vital to our livelihood that it would be practically impossible to revert to the mode of living of fifty years ago. The congestion of population alone would prevent this, for foodstuffs can no longer be raised by even the farmer to satisfy his entire needs. The age of independence in this regard is as much a matter of the past as is the age of home-made clothing. Mankind has simply outgrown the ability to exist without teamwork.

Cold storage, refrigeration and air conditioning spell teamwork to the highest degree. The preparation, transportation and storage of meats, fruits, dairy and poultry products would be impossible without it, even with express freight service.

Refrigeration, as the generally accepted term applied to this industry, includes both the manufacture of ice and the cooling of air in cold storage or air conditioning systems. Most

recent developments in the ice industry have included study of cabinet design, insulation and circulation of air to assure of more constant and uniform temperatures throughout the cabinet as the ice melts, and to eliminate water removal, by permanent drainage.



Courtesy of Howe Ice Machine Company.

Fig. 1—Phantom view of the Howe compressor showing the entire oiling system. In this an oil pressure of from 15 to 30 lbs. is carried on the main bearings. It is regulated by a valve located on the stuffing box bearing, which is designed to by-pass part of the oil from the main oil header. In view of the continuous service to which the oil is subjected, it should be removed at regular intervals of from one to three months for treatment and removal of impurities.

Refrigeration can be direct or indirect. In the former the refrigerant is used directly to manufacture ice or cool the storage compartment or tanks by expanding it in suitable coils located therein. Indirect refrigeration involves preliminary cooling of air by circulating it over ice, brine coils or expansion coils containing the refrigerant, in a separate compartment or bunker room, or otherwise subjecting it to the cooling reactions by means of suitable coils, etc. This cooled air is then passed to the storage compartments, refrigerating rooms or cabinets.

Direct cooling is the more economical procedure, though it may involve more of a possibility of leakage of ammonia gas or such other refrigerant as is used, to perhaps cause inconvenience or trouble.

PRINCIPLES OF OPERATION

The phenomenon of refrigeration involves:

1. Evaporation and expansion of the refrigerant, whereby heat is absorbed from the surroundings and
2. Compression and condensation, whereby this heat is in turn abstracted from the refrigerant and the latter converted to liquid form once again.

How Refrigeration is Accomplished

The various types of refrigerating machines in more or less common use can be definitely grouped into two distinct classifications, according to the methods involved, i.e.:

1. Where refrigeration is produced by the evaporation of some volatile liquid.
2. Where refrigeration is effected by the compression, cooling and expansion of air.

The first classification is of primary interest from the viewpoint of lubrication. It can be subdivided into two groups, according to whether the principles of compression or absorption are employed.

Refrigeration by Compression

The compression process is chiefly used today. Such a system includes a compressor, oil separator, condenser, expansion valve and an evaporator or refrigerator.

Compressors, as designed for manufacture of ice, are of the reciprocating single or double acting type, according to the size of the installation and extent of refrigeration required. In the compression process the refrigerant or cooling agent is recovered after each expansion by means of mechanical compression. With certain variations in construction and arrangement of equipment, the compression process is adaptable to any one of the refrigerating agents in accepted usage today.

In operation, the gaseous refrigerant in a compression system must be sufficiently compressed and cooled to convert it to liquid form. Under compression alone, it will still remain as a gas due to the fact that the application of pressure raises the temperature above the liquefaction point. Some form of condenser must therefore be used.

Prior to condensation, however, the gas in the average commercial or ice plant unit is usually passed through a suitable oil separator or trap in order to free it of any excess lubricant that may have gained entry into the compres-

sor cylinders. From the oil separator the hot refrigerant then passes to the cooling coils of the condenser, where its temperature is sufficiently lowered by means of air or cold circulating water to convert it to liquid form. It is then capable of serving as a cooling medium.

Cooling is brought about by passing it through an expansion or regulating valve to the evaporating side of the system. Here, by virtue of a considerable drop in pressure, it evaporates and takes up heat, returning thereafter to gaseous state once more. In so doing, it cools down to a relatively low temperature, and as a result, absorbs heat from the surroundings, whatever these may be. It is then returned to the compressor to commence this cycle of operation anew.

The Absorption Process

In this process, one takes advantage of the fact that certain low-boiling-point vapors are readily absorbed by water, being capable of subsequent separation by fractional distillation upon the application of heat. Absorption refrigeration involves pumps instead of compressors.

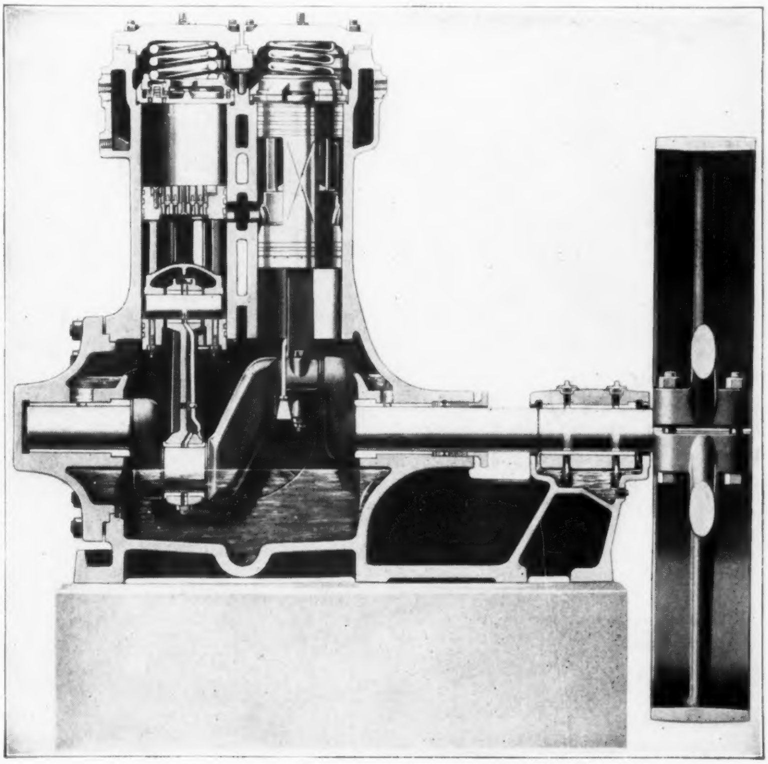
Ammonia is principally used in absorption refrigeration do to its relatively high affinity for water and the readiness with which it can be distilled off under pressure and temperature conditions where water is unaffected. The latter is, therefore, able to remain in a liquid state.

Absorption refrigeration involves three stages or sets of equipment, whereby the ammonia is first distilled in a suitable steam heated generator, freed from any water vapor in an analyzer or rectifier, and liquefied by passage through a suitable condenser. It is then ready for the second, or refrigeration stage, being passed to an evaporator or set of cooling coils.

The third stage usually comprises the passing of the gaseous ammonia under its own pressure to an absorber, where it is taken up by a weak ammonia solution. When suitable concentration of the latter has been attained it is pumped back to the generator and the cycle begun anew.

Refrigerating Elements

A number of chemicals are in commercial use today as refrigerants. Anhydrous ammonia (NH_3), or ammonia free from water, is most commonly used in the manufacture of ice. Under normal conditions this chemical occurs



Courtesy of The Vilter Manufacturing Company.

Fig. 2—Section through a Vilter splash-lubricated compressor. Note level of oil in the oil reservoir. One of the interesting features of this design is the fact that the wrist-pins are lubricated by means of a small ball-type check valve located on the side of the connecting rod bearing. Upon each downward stroke the tube to the wrist pin is charged with oil.

as a gas, but by either or both decreasing the temperature and increasing the pressure it may be readily liquefied. Carbon dioxide (CO_2) can also be used in large tonnage service, or where safety is the primary requirement.

Anhydrous Ammonia in Compression Systems

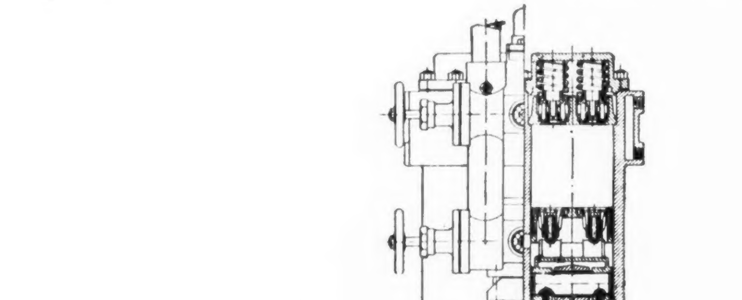
The handling of ammonia in the process of refrigeration can be made to involve either wet or dry compression.

Wet Compression

This is attained either by the introduction of liquid ammonia directly into the compressor cylinders at the beginning of the compression stroke, or by operating so that somewhat more liquid ammonia than can be evaporated is passed into the refrigerator coils.

Subsequently this liquid returns to the compressor with the balance of the refrigerant

which has been vaporized, and is itself evaporated on the suction stroke by the heat of the compressor.



Courtesy of Baker Ice Machine Co., Inc.

Fig. 3—Sectional view of a Baker 2-cylinder vertical fully enclosed compressor. This machine is designed for full force feed lubrication, filtered oil being delivered under pressure through the hollow crankshaft to main and connecting rod bearings, piston pins and shaft packing. It is equipped with a visible oil height indicator gauge, also with an oil pressure regulating valve and pressure indicating gauge.

Valves and cylinder walls are lubricated with oil fed from the oil pump through an automatic pressure regulator and sight glass in the ammonia suction line. The oil pump is a double cut gear, positive pressure, rotary type located in a movable housing and driven directly from the end of the crankshaft.

Dry Compression

Dry compression constitutes the passing of ammonia vapor alone into the compressor. It involves the same operating principles as wet compression with the exception that discharge temperatures are somewhat higher.

Carbon Dioxide

Refrigeration by means of carbon dioxide, or carbonic anhydride (CO_2) as it is also known, involves an arrangement of machinery and equipment much similar to an ammonia compression system. In fact, the essential difference (other than in regard to certain details of construction in view of the higher pressures involved) is in the cooling medium or refrigerant employed.

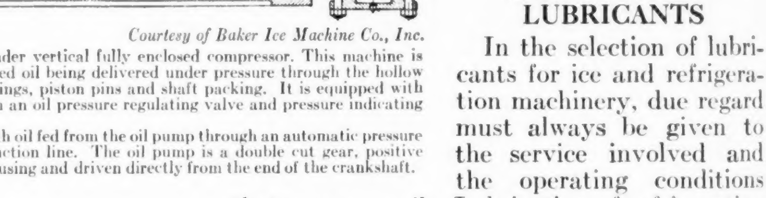
Carbon dioxide is non-explosive, odorless, non-combustible, a fire extinguisher and neutral in its action upon foodstuffs, fabrics and other substances which may require cold storage. Normal leakage is, therefore, not generally harmful even though it may be more prevalent due to the high pressure involved.

Carbon dioxide systems include both horizontal and vertical compressors, according to the type of service and refrigerating capacity involved.

Single and double acting compressors are in use, but due to the difficulty in maintaining tight stuffing boxes the single acting machine is often preferred. Frequently pressures as high as 1000 pounds or more may be necessary; therefore, it is evident that the system must be tight and of exceptional rigidity.

SELECTION OF LUBRICANTS

In the selection of lubricants for ice and refrigeration machinery, due regard must always be given to the service involved and the operating conditions that may prevail. Lubrication of refrigerating machinery is unique in that one must consider the action and effects of the lubricants upon parts not requiring lubrication, as well as upon

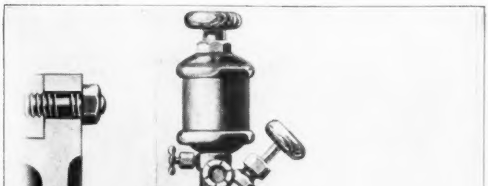


Courtesy of Ingersoll-Rand Company.

Fig. 4—Showing a type of ammonia stuffing box as applied to an Ingersoll-Rand ammonia compressor. This design includes special metallic packing, water jacketing, force feed lubrication and venting to the intake to reduce ammonia loss. In particular note the depth of the stuffing box and manner in which packing is applied.

the actual wearing surfaces. To overlook or disregard the importance of such factors as the method of lubrication, the temperature in the expansion or refrigerating coils, the mechanical condition of the compressor, etc., and the location, type and efficiency of the oil separator may frequently lead to marked increase in maintenance costs and reduction in capacity.

Oil congealed in any part of a cooling system will tend to reduce refrigerating efficiency due to its becoming so sluggish under the low temperatures involved as to form an interior lining in the expansion coils and materially affect the heat transfer. An oil for refrigerating machinery lubrication must, therefore, remain fluid at the lowest temperatures to which it may be subjected during operation. These temperatures will be encountered in the expansion or refrigerating side of the system, or, in other words, beyond the expansion valve. There are many oils, of course, which, by virtue of their base and degree of refinement, will not be able to withstand lower

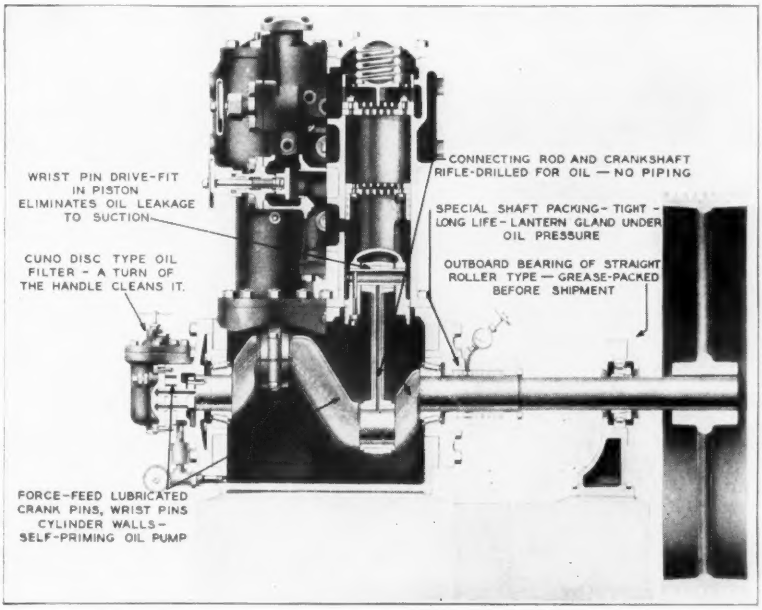


Courtesy of Frick Company, Inc.

Fig. 6—Cutaway view of the Frick type stuffing box, showing means for sight lubrication.

temperatures without congealing to a certain extent, depending upon the wax content.

When congealment occurs a film of oil will be deposited on the inner surfaces of the refrigerating piping to form more or less of an insulating medium which will prevent proper ab-



Courtesy of Carbondale Machine Corporation (Unit of Worthington Pump & Machinery Corp.)

Fig. 5—Showing the outstanding features of the Carbondale roller bearing duplex refrigeration compressor. Complete force feed lubrication is provided for to serve the crank pins, wrist pins and cylinder walls. In this connection a self-priming oil pump is used. Note also that the oil lantern gland is kept under oil pressure.

straction of heat from the compartment or medium which is to be cooled. If this is allowed to continue it is evident that the refrigerating capacity of the system will be reduced and ultimately it will be necessary to clean out these congealed oil deposits. Consideration must also be given to water. It is essential that the oil at all times be practically free from water, otherwise this will freeze if carried over to the refrigerator coils, in which case it would probably remain in the system and result in a certain decrease in evaporative efficiency. Water may also freeze to ice in certain of the valves to also cause trouble.

Types of Lubricants

For normal ammonia compressor service a straight mineral filtered oil having a viscosity around 150 seconds Saybolt at 100 degrees Fahr., will be necessary where the temperature in the refrigerating coil is below 5 degrees Fahr. Above this temperature, however, an oil of somewhat higher viscosity; i.e., 200 to 300 seconds Saybolt, will give more satisfactory results.

A highly refined straight distilled mineral oil is always advisable in order that the above requirements will be adequately met. Oils of this nature will have a sufficient range of physical

properties to lubricate an ammonia compressor effectively under all normal operating conditions.

Mineral oils are more suitable than compounded lubricants inasmuch as animal and vegetable oils will not only have a tendency to congeal at low temperatures and gum at higher temperatures, but will also react to a certain extent with ammonia to cause the formation of sludge.

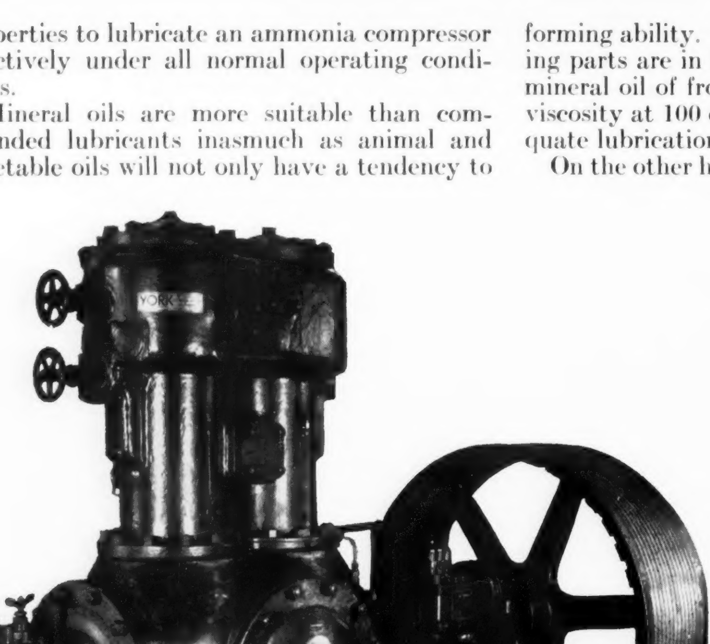


Fig. 7—A typical vertical reciprocating refrigeration compressor showing relative location of the mechanical force feed lubricator with piping therefrom, also other piping essential to oil circulation elsewhere within the machine.

When Viscosity Must be Considered

Viscosity is a factor where enclosed crankcase, high speed machines are used in connection with evaporating systems which may allow liquid refrigerant to return to the compressor. As a rule, oils should be used which will stand considerable churning in the presence of the refrigerant and a certain amount of water.

The one oil often lubricates the entire machine. As a result, it must be capable of serving both the cylinders and the bearings. It should not emulsify to any great extent, for this might result in clogging of the lubricating system or impairment of refrigeration should it work past the piston rings and over to the refrigerating side.

The physical condition of the valves, piston rings and stuffing boxes must also be considered in deciding upon the viscosity of oil to use. Practically as important as its lubricating properties will be the seal and compression-forming ability. If the cylinder walls and moving parts are in first-class condition, a straight mineral oil of from 150 to 200 seconds Saybolt viscosity at 100 degrees Fahr., should give adequate lubrication.

On the other hand in large machines, or those where the cylinder walls are scored or rings are worn, an oil of higher viscosity may be essential to maintain the requisite seal and degrees of compression. Under such conditions an oil having a viscosity around 300 seconds Saybolt at 100 degrees Fahr., should be satisfactory.

Valve Design

Changes in compressor design over recent years have lead to conditions involving a variety of lubrication problems which were not prevalent theretofore. In this regard valve design must be carefully considered, viz., when we used to have to deal with compressors equipped with poppet valves, clearance spaces were held to a minimum. The use of plate valves today, however, requires the separation of the plates with grid work; it is this latter which necessarily imposes an added clearance volume in the head of the machine or at the top of the piston.

In operation, with the older type poppet valve machine (especially in vertical location), if the expansion valve was slightly overfed and liquid ammonia reached the machine there might be a great deal of slamming of the safety head, which would make sufficient noise to alarm the attendant and cause him to cut back on the expansion valve. With the grid type valve, however, a large quantity of refrigerant can pass through the machine without any appreciable knocking or noise, and the condition can proceed without even attracting the attention of the attendant. The net result of large quantities of refrigerant passing through the compressor is the lowering of the temperature of the cylinder walls to a point below which condensation takes place upon the slightest compression.

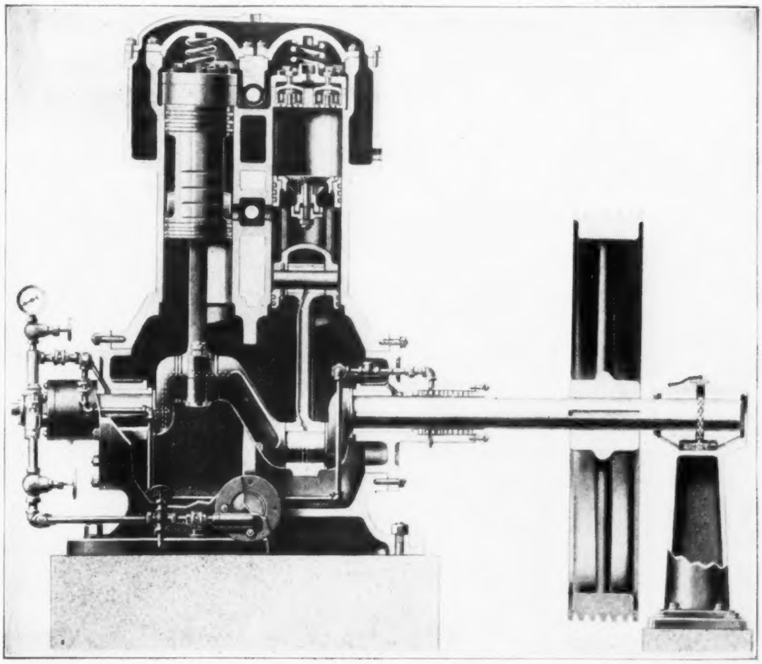
With refrigerants such as ammonia, condensation on the wall of a vertical cylinder washes the lubricant from the cold side and scoring of the surface or wear of the piston rings results. This condition does not occur in a horizontal

machine for the reason that the gas in nearly every case enters at the same end at which it is discharged, therefore, the cold gas is more or less immediately mixed with the remaining hot gas in the compressor. The obvious remedy for such a condition is to locate some form of suction trap in the suction line which will lower the velocity of the incoming gas and cause it to trap out the liquid. Such a trap should be provided with a small coil through which the refrigerant may be passed on its way to the evaporator; this will act as an auxiliary evaporator of any entrapped liquid.

An opposite condition prevails, however, where a flooded system is so arranged that the gas velocities are very low. In this case the gases arrive at the machine comparatively highly saturated. This in turn results in a high discharge temperature, and if the lubricant is not of sufficient lubricating ability at these higher temperatures; i.e., 220 to 350 degrees Fahr., it may not be able to adequately protect the cylinder walls and rings against abnormal wear. When the amount of superheat is sufficiently great to cause extremely high discharge temperatures (as might occur where the ratios of compression are very great), a liquid injector can be located adjacent to the machine to reduce the temperature of the incoming gas to a point nearer to saturation, or 2-stage compression can be adopted. It is advantageous to locate such an injector in the suction line at a point sufficiently distant from the compressor so that a thermometer can be placed close to the compressor in order to observe the effect of liquid injection.

Carbon Dioxide Service

Lubrication of a carbon dioxide compressor is similar to an ammonia job as far as design and construction are concerned. The higher pressures involved, however, often require a heavier oil. So we can state in general that the oil should be a straight mineral, highly refined product having essentially the same characteristics as for a dry ammonia compression system, viz., low pour test, and a flash point sufficiently above the discharge temperature to insure against excessive vaporization. The viscosity, however, may have a range from 200 to 300 Saybolt at 100 degrees Fahr., dependent upon operating conditions and the pressures involved. Cylinder temperatures in a carbon dioxide compressor are comparatively high,



Courtesy of Frick Company, Inc.

Fig. 8—Cutaway view of a comparatively large size ammonia compressor showing means provided by Frick Company for force feed lubrication. By careful study of this design path of circulation of the oil can be traced from the pump through the main bearings and upward along the connecting rods to the wrist pins. Note relative location of oil leads to the main bearings, stuffing box, the gauge and oil strainer.

in line with the pressures which will prevail.

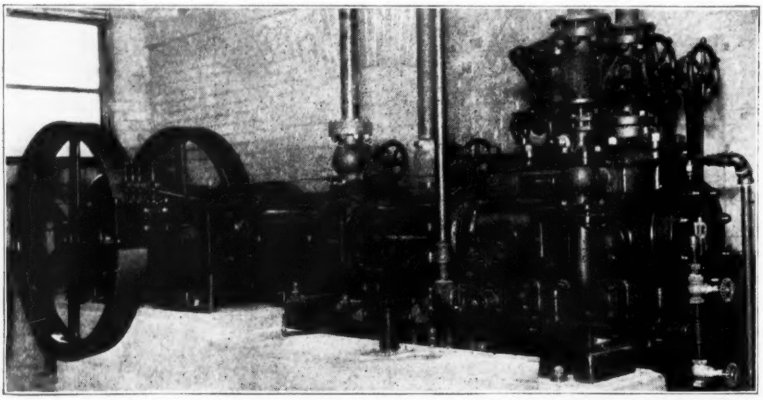
Mineral oil, has no affinity for carbon dioxide, hence there is little or no possibility of its being carried over into the condenser unless it is vaporized. This is not likely to occur, however, when using an oil which is suited to the requirements. On the other hand, to insure against any oil whatsoever passing over into the system, an oil trap is usually installed in the discharge line from the compressor.

Stuffing boxes are built similar to those on a double-acting ammonia compressor, with the exception that the higher pressures involved require more compartments to prevent leakage. Force-feed lubrication is the usual means provided for oiling the piston rod and maintaining an adequate stuffing box seal; the same lubricator also serving the compressor valves and cylinders. The feeding of a suitable amount of lubricant to the stuffing box prevents loss of gas. The lubricator must be very carefully adjusted at all times, however, the same as for an ammonia compressor, since the feeding of an excessive supply of oil will often result in a

certain amount of it passing to the gas relief line and thence into the system.

LUBRICATING SYSTEMS

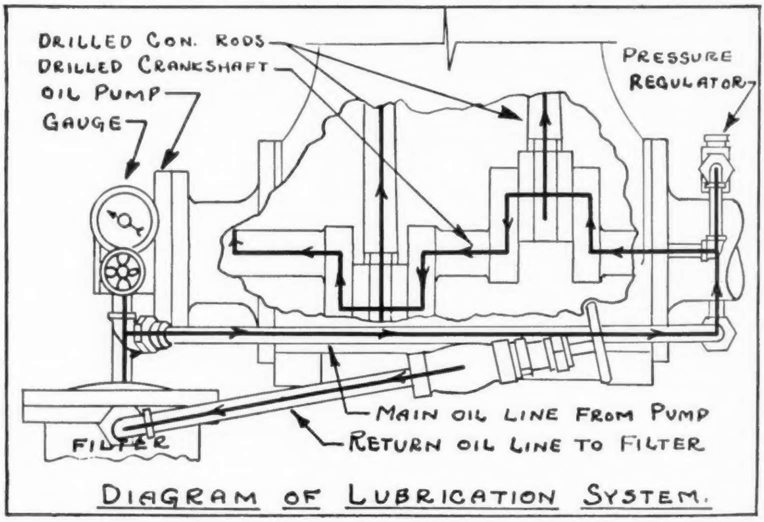
Splash and pressure lubrication predominate in the heavy duty, industrial refrigerating compressor. The latter is suited for the lubrication of both vertical and horizontal machines. The former, however, is more adapted to the vertical compressor.



Courtesy of Ingersoll-Rand Company.

Fig. 9—A steam driven ammonia compressor showing in particular the location of the mechanical force feed lubricator and the accessibility of this unit adjacent to the compressor.

The system involved for the lubrication of compressor cylinders, stuffing boxes and enclosed bearings will have a decided influence upon the grade of the oil that should be used.



Courtesy of Howe Ice Machine Company.

Fig. 10—Diagrammatic view of the lubricating system of a Howe compressor showing in complete detail the path followed by the oil, both through the main line from the pump and via the return oil line to the filter.

Splash Lubrication

In a splash lubrication system oil is distributed at each revolution of the crank, the level in the crankcase being maintained just high enough to permit the crank to dip and splash the necessary amount of oil to the cylinder walls. Continued operation will result in the crankcase being filled with a lubricating vapor above the main body of oil which will insure adequate lubrication of main, wrist pin and crank pin bearings.

Careful attention is necessary, especially when recharging the case with oil, to see that the level is not raised too high. The result would be churning by the crank, bringing about such violent agitation in the main body of oil as to oftentimes preclude effective precipitation of any solid impurities that may have gained entry. There would also be possibility of loss of lubricant past the piston rings, with subsequent entry of an excess of oil into the condensing and evaporating parts of the system.

Piston Ring Fit

When piston rings are not sufficiently tight, however, if the crankcase contains too much oil or agitation is too violent, the excess which naturally will reach the cylinder walls will tend to work past the rings, just as so frequently occurs in an automobile engine. This is often termed oil pumping. This is not only wasteful, but also a detriment, for oil in the refrigerating lines will impose an added load on the oil separator. Furthermore, if by chance the oil is not of sufficiently low pour test there will be possibility of its congealment within the system, with reduction in the amount of refrigeration developed. Even with rings in good condition oil pumping is often due to faulty design of the evaporator, or careless operation whereby liquid refrigerant enters the cylinders from the evaporator.

Use of excess oil in a splash lubricated system will also involve the possibility of difficulty when draining and cleaning, especially where sludging has taken place. Continued churning

of improperly refined oils will cause sludge formation. In part this is due to oxidation; it will be most probable where water is present or the oil is laden with very much foreign matter, such as dirt, metallic particles, or carbon. Regular periods for cleaning must therefore be established with study of the condition of the used oil, for this will very often indicate both the approximate suitability of the latter and the extent to which effective lubrication is practicable.

Pressure Systems

Where larger types of vertical or horizontal refrigerating machines are involved, pressure lubrication is used with marked success. Pressure assures of quite accurate control of the amount of oil delivered to cylinder walls and compressor bearings. There is another advantage also; i.e., the possibility of effective filtration or purification of the oil where there is provision for circulation.

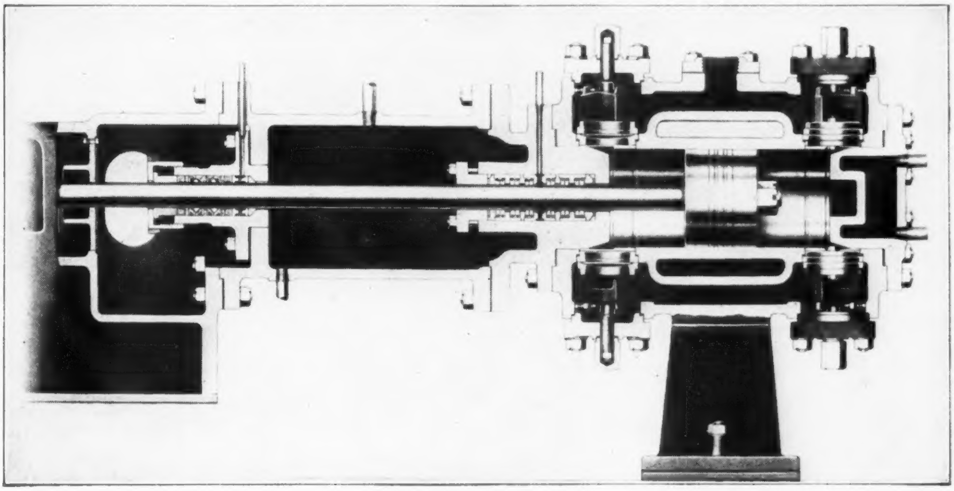
Mechanical Force Lubricators

External lubricators of this type are extensively used where compressor cylinders only are to be pressure oiled. Excellent economy will be attained by regulating such lubricators so that just enough oil is delivered to maintain the requisite lubricating films, with the least amount of excess.

On many types of machines, it is good practice to lubricate internal and external parts individually. In other words, using the mechanical lubricator with perhaps three outlets for cylinder and stuffiing box service, and an independent gravity or mechanical pressure circulating system for all external bearings.

Mechanical force feed lubricators are especially adapted to cylinder and rod lubrication via the oil lantern, or oil recess within the piston rod stuffing box. By properly constructing a stuffing box with a lead to come from the lubricator, it is possible to operate the piston rod continually through a ring of oil. In this way, effective rod lubrication, as well as sealing against pressure, are maintained.

To lubricate the cylinders in addition, in some designs it is only necessary to deliver a certain excess of oil to the stuffing box lantern and provide a so-called overflow pipe to carry this to the refrigerant suction line adjacent to the cylinder. In effect, this is similar to the principles of steam cylinder lubrication, the refrigerating gas being impregnated with vaporized lubricant prior to its passage through the compressor.



Courtesy of Carbondale Machine Corporation.
(Unit of Worthington Pump & Machinery Corp.)

Fig. 11—A Carbondale horizontal ammonia cylinder provided with a double seal stuffing box. In this design oil is delivered by a force feed lubricator to the cylinder barrel and to the inner and outer packings; a vent and drain being provided to the double seal housing so that pressure in the latter never exceeds that of the low side, also any oil accumulation can be drained off.

Hand pump oilers can also be used for this purpose, but mechanical force feed lubricators are more positive and require less attention on the part of the operator.

Vertical compressors of the enclosed crankcase type are most suitable for automatic controlled systems, which are usually of comparatively small capacity, also systems where very little attendance is available. In the vertical machine the side thrust is taken directly by the cylinder wall which tends to make the cylinder wear to oval shape. This thrust varies at different points of the stroke so that the wear on the cylinder wall is not even over the entire stroke.

Horizontal compressors on the other hand have connecting rods two or three feet longer than vertical machines, and the component of thrust at right angles to the travel of the piston is far less in a horizontal machine. This thrust is taken up by the crosshead guides which are readily accessable for adjustment. The only wear in the cylinder therefore, is caused by that part of the piston weight which is unbalanced by the pressure of the guide and long stuffing box.

OIL SEPARATOR OPERATION

Wherever an excess of oil may find its way to the evaporating or cooling side of a refrigerating system, certain detriments will be involved, as already mentioned. In this connection, it is interesting to discuss the means whereby this is normally prevented by use of an oil separator.

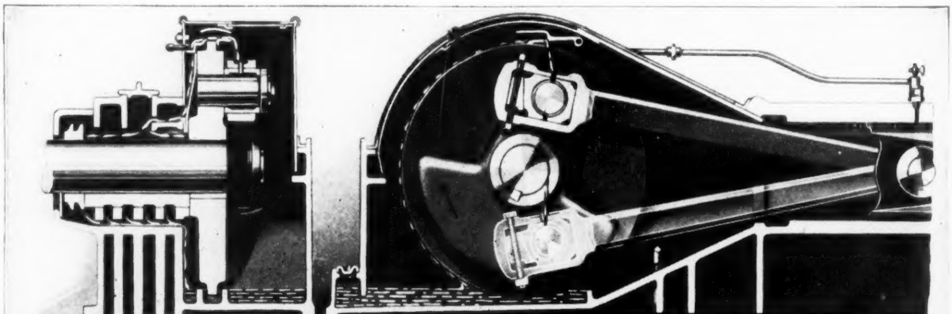
This unit serves to remove any particles of oil from the refrigerant while it is in gaseous form, after it has left the compressor. The larger the oil particles, of course, the more effective will be the separator. It should, therefore, be located at a sufficient distance away from the compressor to permit of adequate precipitation of the oil within the ammonia or carbon dioxide gas.

The capacity of any separator should be ample so that the velocity of the gas passing through will not be too high. But we must realize that should an excessive amount of oil be fed to the compressor, a heavy load will be imposed upon the oil separator.

Location and Installation

The manner of location of such a device is very important. In general, it should be placed between the discharge of the compressor and the point of entry of the gas into the condenser. In certain machines, a drain valve also may be installed below the condenser to enable removal of any oil that may have passed the separator. Where the oil fails to function properly, the reason is often because the separator is set too near the compressor, the rush of hot gas preventing proper condensation and collection of the oil.

Oil will be practically always vaporized to a certain extent by virtue of the heat of compression which is prevalent. This oil vapor will naturally tend to pass into the system with the refrigerant, to condense and remain in the colder parts, unless it is effectively removed before it enters the condenser. In consequence, the separator should be located as close to the condenser and as far away from the compressor as possible. It is always advisable that it should be of sufficient size to allow of ample reduction in the velocity of the gas in order to permit of effective separation. A smaller separator located some distance from the compressor may often prove more effective than a large separator located nearby.



Courtesy of Ingersoll-Rand Company.

Fig. 12—View of the crankcase elements of a horizontal Ingersoll-Rand compressor, showing manner in which oil is scooped and distributed at every rotation of the crank, to the crank pin bearing and crosshead guides. This is a completely automatic system of lubrication, the entire unit being carefully housed to prevent contamination of oil from foreign matter. Arrow indicates direction of rotation.

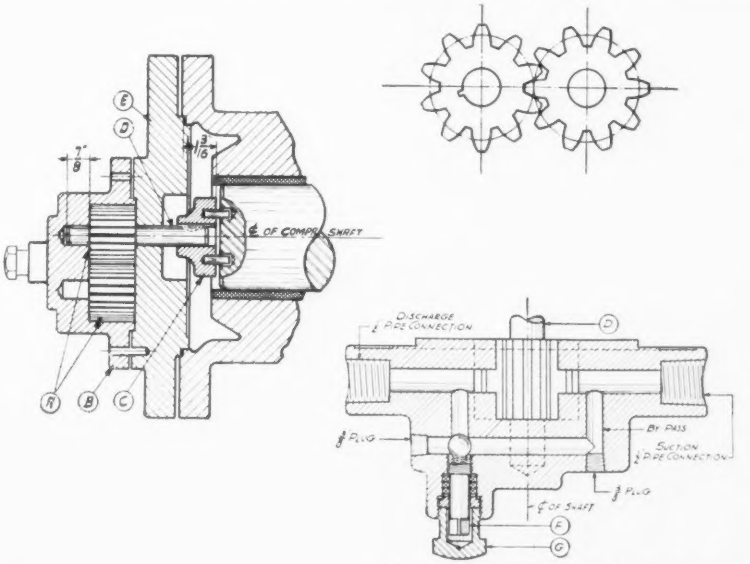
Where it is impossible to locate the main oil separator elsewhere than adjacent to the compressor, it is well to use an oil of as low an atomizing tendency as possible. This property will usually accompany high viscosity. The choice of a heavier oil would, therefore, solve the problem to some extent. In general, an oil of a viscosity of about 200 seconds Saybolt at 100 degrees Fahr., will meet these conditions.

The efficiency of an oil separator can be checked by comparing the amount of oil removed from it with the amount fed to the compressor. Any extensive difference would indicate that the oil is not being entirely removed

or trapped. Allowance, of course, should be made for oil leakage around the stuffing box, although to just what extent this may occur will depend on the individual installation, the care given to lubrication, and the original viscosity of the oil.

SEALING THE STUFFING BOX

With compressors using either ammonia or carbon dioxide, one of the most important factors is to maintain suitable stuffing box seals and properly lubricated piston rods. With ammonia it is necessary to remember that this chemical has a certain corrosive action upon brass, copper and bronze. Stuffing boxes, for such service, are, therefore, usually built of cast iron or steel, using metallic (babbitt metal), asbestos, or rubber packing.



Courtesy of The Vilter Manufacturing Company.

Fig. 13—The gear design on the force feed oil pump for vertical twin cylinder ammonia compressors of the Vilter type. At lower right is also shown means for regulating oil pump pressure by turning stem "F" in one direction or another until the oil gauge registers the proper pressure. The stem, however, should never be turned down to its limit, otherwise the excess pressure developed may burst the oil gauge.

The "Oil Lantern"

In some types of machines a hollow space or "oil lantern" is located between two separate sets of packing. This space surrounds the rod and is filled with oil. It not only serves as a seal to prevent loss or leakage of ammonia or carbon dioxide, but also serves as an effective means for piston rod lubrication. Lubricant is usually fed to the "oil lantern" by means of a hand or automatic pressure oil pump.

Where the piston rod is efficiently lubricated, its surface will have a smooth gloss and will show a light film of oil; there will be no indication of overheating, and a relatively perfect seal will be maintained with a minimum of leakage.

In some types of double-acting machines, the "oil lantern" serves also as a means of introducing the lubricant to the compressor cylinder by allowing oil to work past the piston rod packing. There is an added advantage to this method in that certain grades of packing, which might be reacted upon by ammonia gas, will be protected by the lubricant. The "lantern" can also be connected to the suction so that the outer set of packing is under low pressure.

More usual practice in cylinder lubrication, however, is to design compressors for pressure lubrication, using a positive oil pump or force feed lubricator which is driven from the reciprocating mechanism through suitable connecting links or gearing.

Force feed lubrication is advantageous in that the amount of lubricant supplied to the compressor is dependent upon the speed of operation. It is, therefore, positive, economical and requisite of little attention on the part of the engineer, excepting when it is necessary to refill the lubricator. Thus, by careful adjustment and correction, it is possible to feed a definite quantity of lubricant at each stroke and at just the right time to be most effective.

RECLAIMING COMPRESSOR OILS

It is practicable to reclaim oil from an ammonia compression system by installing an ammonia distilling apparatus. This device has the dual advantage of both recovering the oil and purifying the charge of ammonia to keep it in a pure anhydrous condition without interfering with the continuous operation of the plant.

Such equipment can be connected to the discharge line oil separator and the bottom of the liquid ammonia receiver, from which oil and other impurities may be drawn, for subsequent distillation of ammonia.

After all the liquid ammonia has been evaporated and returned to the suction line of the system, the oil can then be drawn from the bottom of the still, using suction pressure for this purpose. Such oil as is drawn off will contain a certain amount of gas. It should, therefore, be set aside until the gases have freed

themselves. The application of a little heat will assist this operation materially. The rate of distillation should be controlled to prevent too rapid evaporation, which will cause a boiling-over effect and the loss of a large proportion of oil through passage back to the suction line.

After removal of the oil from the distilling system it is ready to be filtered. A separate filter should be used for this work. The size and type of filter will depend upon the size of the plant and the amount of oil to be handled. Providing the original oil has been chosen with a view to giving most effective lubrication the oil recovered from the distiller can again be used for compressor lubrication after careful filtration.

In many plants where oil is reclaimed, however, it is used for external lubrication only and new oil is employed for the lubrication of cylinders and other internal parts. This is safe practice, and an assurance that the oil used where service is most severe is perfectly clean and up to specifications.

EXTERNAL LUBRICATION

The so-called external parts in the average horizontal compression ice plant or cold storage unit, such as the crank pins, bearings and guides, involve but few difficulties as a rule in their lubrication. In general, this is automatic, it being customary to employ splash or force feed lubrication on most machinery. For such service a high grade engine or machine oil of light to medium viscosity can generally be used. Low pour test or exacting flash point requirements for this type of work are relatively immaterial; it is only essential that the viscosity be sufficient to carry the prevailing bearing loads, and that the oil is conducive to ready separation from foreign matter and impurities.

In many types of vertical compressors, however, splash lubrication is used; the same oil frequently serving both the compressor cylinder and the bearings in much the same manner as in an automobile engine.

Horizontal compressors and certain larger types of vertical machines are usually equipped with a gravity or force feed lubricating system, which furnishes a continuous stream of oil to all bearings beyond the compressor cylinders. Such systems generally include a suitable oil filter, over-head storage tank (which allows for gravity feed), water separator and pump. This latter is installed in the base of the crankcase, being driven from the compressor itself.

CONCLUSION

In the above discussion it has been practicable to deal only with the basic mechanical principles of refrigeration compressor lubrication. There is a definite relation to chemistry, however, which must not be overlooked. This has been most forcibly demonstrated in connection with electric refrigeration and air conditioning, wherein refrigerants such as sulfur dioxide, methyl chloride, and Freon, etc., are involved; it is not so pronounced with ammonia and even less so with carbon dioxide. In any case the possibility of chemical reactions occurring within the system will depend upon the purity and chemical stability of both the refrigerant and lubricating oil. In the conventional ammonia system, as adapted to ice refrigeration, sludge formation must be prevented as far as possible. The use of high grade ammonia, lubricating oils refined especially to insure of maximum resistance to breakdown, and maintenance of a relatively water free system will be best assurance of cleanliness within the entire system. Obviously, as this is predicated upon absence of sludge, more dependable compressor operation will result through maximum protection of all moving parts.

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TEXACO LUBRICATION RECOMMENDATIONS

for

ICE REFRIGERATION COMPRESSORS

★ SPLASH, FORCE-FEED OR GRAVITY CIRCULATING SYSTEMS ★

Where the oil may gain entry into the refrigeration system or compressor cylinder . .	TEXACO Capella Oils
Where there is no danger of this occurring	
In Force-Feed or Gravity Systems . . .	TEXACO Alcaid Oil or Algol Oil
In Splash Systems	TEXACO Capella Oil C

★ STEAM CYLINDER LUBRICATION ★

Where separation of oil from condensate is not important	
Saturated Steam (Above 150 lbs. pressure)	TEXACO Leader Cylinder Oil or TEXACO Cavis Cylinder Oil
Saturated Steam (Below 150 lbs. pressure)	TEXACO Pinnacle Cylinder Oil or TEXACO Draco Cylinder Oil
Where the condensate is used for ice making or core filling	
Saturated Steam (Above 150 lbs. pressure)	TEXACO Cavis Mineral Cylinder Oil or TEXACO 650 T Mineral Cylinder Oil
Saturated Steam (Below 150 lbs. pressure)	TEXACO Pinnacle Mineral Cylinder Oil

★ ELECTRIC MOTORS ★

Ring Oiled	
Normal Temperatures	TEXACO Capella Oil C or TEXACO Canopus Oil
Low Temperatures	TEXACO Capella Oil A or B
Ball and Roller Bearings	
Oil Lubricated	TEXACO Canopus, Cetus, or Alcaid Oils
Grease Lubricated	
Light to Medium Duty	TEXACO Starfak Grease No. 2
Heavy Duty	TEXACO Marfak No. 2
Wick or Wool Yarn Systems	
According to size	TEXACO Cetus Oil or TEXACO Alcaid Oil

THE TEXAS COMPANY